

NO-A178 995

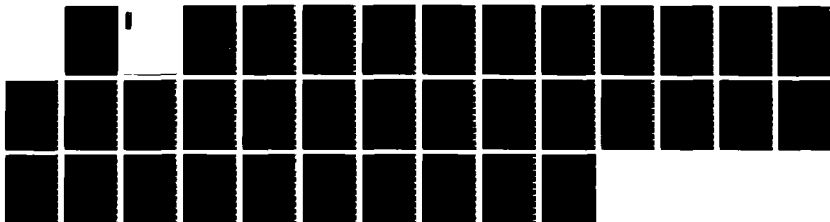
EVALUATION OF USED AUTOMOTIVE OIL COFIRING PRACTICES
FOR COMPLIANCE WITH (U) NAVAL SURFACE WEAPONS CENTER
DAHLGREN VA M A ROBINSON MAY 86 NSWC/TR-86-89

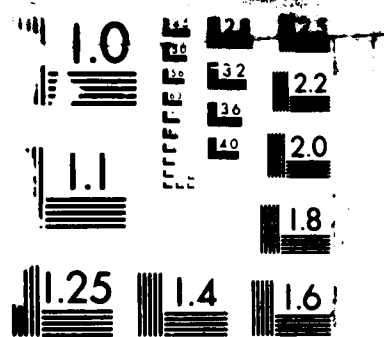
1/1

UNCLASSIFIED

F/G 13/2

NL





MIC

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

A178995

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER NSWC/TR 86-89	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) EVALUATION OF USED AUTOMOTIVE OIL COFIRING PRACTICES FOR COMPLIANCE WITH USED OIL REGULA- TIONS AND ENVIRONMENTAL QUALITY REQUIREMENTS		5. TYPE OF REPORT & PERIOD COVERED 9/85 - 3/86
7. AUTHOR(s) M. A. Robinson		6. PERFORMING ORG. REPORT NUMBER
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Surface Weapons Center (H31) Dahlgren, VA 22448-5000		8. CONTRACT OR GRANT NUMBER(s)
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Facilities Engineering Command (Code 032P) 200 Stovall Street Alexandria, VA 22332		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS PE 63721N S Task Area Y08175L H31
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		12. REPORT DATE May 1986
		13. NUMBER OF PAGES 38
		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution is unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) lubricating oil; air dispersion modeling boilers automotive oil; lead; fuel oil, reclaimed cofiring hazardous wastes; used oil used oil fuel		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Cofiring of used automotive oil in Navy boilers was examined with regards to used oil regulations and environmental impact. Air dispersion modeling of a boiler cofiring used automotive oil was also performed.		

APR 8 1987

A

87-4-7-111

DD FORM 1473
1 JAN 73EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-LF 014-6601

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

FOREWORD

This study of the cofiring of used automotive oil in Navy boilers was sponsored by the Naval Facilities Engineering Command (NAVFAC 032P) under program element 63721N, Task Area Y0817 SL. It examines the used oil regulations and environmental quality requirements involved with used automotive oil cofiring. The results of the air dispersion modeling of a boiler cofiring a used automotive oil are also included.

This report has been reviewed by J. L. Brumfield, Head, Chemical Systems Branch and H. O. Oliver, Head, Survivability Division.

Released by:

R. T. RYLAND, Jr., Head
Protection Systems Department



Accession For
New York
Library
of Congress
Reading Room

Box 1

A-1

CONTENTS

	<u>Page</u>
INTRODUCTION.....	1
CURRENT REGULATIONS ON USED OIL BURNING.....	1
FUTURE REGULATIONS ON USED OIL BURNING.....	3
IMPACT OF REGULATIONS ON COFIRING.....	3
LEAD CONCENTRATION IN USED AUTOMOTIVE OIL.....	4
LEAD CONCENTRATION IN FUEL OIL RECLAIMED (FOR).....	5
AIR DISPERSION MODELING.....	5
MODELING OF BOILER AT A TYPICAL NAVY FACILITY.....	5
AVAILABLE GUIDANCE ON THE BURNING OF USED OIL.....	7
RECOMMENDATIONS.....	8
REFERENCES.....	9
APPENDIXES	
A--RESULTS OF USED AUTOMOTIVE OIL BURNING SURVEY.....	A-1
B--RESULTS OF COMPUTER MODELING FOR A TYPICAL NAVY FACILITY.....	B-1
DISTRIBUTION.....	(1)

TABLES

<u>Table</u>		<u>Page</u>
1	USED OIL FUEL SPECIFICATIONS.....	2
2	LEAD CONCENTRATION IN SAMPLES.....	4
3	BOILER DATA.....	6
4	COMPARISON OF AMBIENT AIR CONCENTRATIONS.....	7
B-1	ANNUAL MEAN CONCENTRATION ($\mu\text{g}/\text{m}^3$) AT EACH RECEPTOR (Pb = 100 ppm).....	B-3
B-2	HIGHEST 24-HOUR CONCENTRATION ($\mu\text{g}/\text{m}^3$) AT EACH RECEPTOR (Pb = 100 ppm).....	B-4
B-3	HIGHEST 8-HOUR CONCENTRATION ($\mu\text{g}/\text{m}^3$) AT EACH RECEPTOR (Pb = 100 ppm).....	B-5
B-4	ANNUAL MEAN CONCENTRATION ($\mu\text{g}/\text{m}^3$) AT EACH RECEPTOR (Pb = 75 ppm).....	B-6
B-5	ANNUAL MEAN CONCENTRATION ($\mu\text{g}/\text{m}^3$) AT EACH RECEPTOR (Pb = 50 ppm).....	B-7
B-6	TEN HIGHEST 24-HOUR CONCENTRATIONS (Pb = 100 ppm).....	B-8
B-7	TEN HIGHEST 8-HOUR CONCENTRATIONS (Pb = 100 ppm).....	B-8
B-8	TEN HIGHEST 1-HOUR CONCENTRATIONS (Pb = 100 ppm).....	B-8
B-9	TEN HIGHEST 24-HOUR CONCENTRATIONS (Pb = 75 ppm).....	B-9
B-10	TEN HIGHEST 8-HOUR CONCENTRATIONS (Pb = 75 ppm).....	B-9
B-11	TEN HIGHEST 1-HOUR CONCENTRATIONS (Pb = 75 ppm).....	B-9
B-12	TEN HIGHEST 24-HOUR CONCENTRATIONS (Pb = 50 ppm).....	B-10
B-13	TEN HIGHEST 8-HOUR CONCENTRATIONS (Pb = 50 ppm).....	B-10
B-14	TEN HIGHEST 1-HOUR CONCENTRATIONS (Pb = 50 ppm).....	B-10

INTRODUCTION

The U.S. Navy is concerned with finding alternate disposal methods for used oils generated at naval facilities. The cofiring of used automotive oil in Navy boilers is an alternative to the current disposal methods for this used oil. Cofiring provides ultimate disposal of this waste along with a savings on boiler fuel. However, recent Federal regulations limit the burning of used oil for energy recovery; and future regulations may include used oil as a hazardous waste. With regards to the cofiring of used automotive oil, this study was primarily concerned with the lead emissions from boilers burning this used oil.

This report (1) examines how these regulations will affect the cofiring of used automotive oil in Navy boilers, (2) demonstrates how air dispersion modeling can be used to show what impact cofiring used automotive oil will have on the ambient air quality (directly affecting the ambient air quality is the lead concentration of the used oil burned in the boilers), and (3) discusses the issue of whether or not the Navy should consider adopting a lower specification for the lead concentration in used oil fuel than is presently required in the regulations. For background information, refer to the *Initiation Decision Report on Thermal Destruction of Hazardous Wastes in Navy Boilers and Incinerators*.¹

CURRENT REGULATIONS ON USED OIL BURNING

On 29 November 1985, the Environmental Protection Agency (EPA) issued new regulations under the Resource Conservation and Recovery Act (RCRA) covering the burning of used oil and hazardous waste for energy recovery (40 CFR Part 266--*Standards for the Management of Specific Hazardous Wastes and Specific Types of Hazardous Waste Management Facilities*²). These regulations distinguish between a used oil and a hazardous waste in setting the restrictions in burning for energy recovery. Also included is a used oil specification that limits the types of boilers that can burn used oils that fail the specification.

Various used oils can be classified as a characteristic hazardous waste under 40 CFR 261, Subpart C--*Characteristics of Hazardous Waste*, which lists two of the characteristics as Ignitability and EP Toxicity. This is important, since used automotive oil may meet the EP Toxicity characteristic for lead and be considered a hazardous waste. However, under the new regulations, a used oil that is also a characteristic hazardous waste is regulated under Subpart E--*Used Oil Burned for Energy Recovery* and not under Subpart D--*Hazardous Waste Burned for Energy Recovery*.

In Subpart E of the regulations, a used oil is defined as "any oil that has been refined from crude oil, used, and as a result of such use, is contaminated by physical or chemical impurities." Any fuel produced by blending, processing,

or other treatment of a used oil is a used oil fuel. Used oil fuel that cannot meet the specifications given in Table 1 is an off-specification used oil fuel. Lead is the constituent that may cause untreated used automotive oil to fail the specifications. Blending of the off-specification used oil with virgin fuel oil will usually be the easiest means of treating it to meet the specifications.

TABLE 1. USED OIL FUEL SPECIFICATIONS

<u>Constituent/Property</u>	<u>Allowable Level</u>
Arsenic	5 ppm maximum
Cadmium	2 ppm maximum
Chromium	10 ppm maximum
Lead	100 ppm maximum
Flash Point	100 °F maximum
Total Halogens	4000 ppm maximum

Off-specification used oil fuel is regulated as to what type of devices can use it as a fuel. They are limited to industrial furnaces, industrial boilers, utility boilers, and used oil-fired space heaters as defined in the regulations. Industrial boilers are "boilers located on the site of a facility engaged in a manufacturing process where substances are transformed into new products." Utility boilers are "boilers used to produce electric power, steam, or heated or cooled air or other gases or fluids for sale." It is unknown if Navy boilers will be considered in either of these two categories. Used oil fuel that meets the specification can be burned in any boiler regardless of function. Off-specification used oil fuel is also subject to record keeping and analysis requirements that are different from those for used oil that meets the specifications.

The following is a summary of the analysis and record-keeping requirements most applicable to Navy facilities wishing to cofire used automotive oil. A Navy facility blending an off-specification used oil fuel (used automotive oil) to meet specifications must obtain analysis or other information to prove that the resulting used oil fuel does meet the specifications. These records must be kept for 3 yrs. The facility must also notify the EPA or state, if authorized, of its used oil management activities. This will be required even if the facility previously notified the EPA of hazardous wastemanagement activities and obtained a U.S. EPA Identification Number. The burning of off-specification used oil fuel requires the burner to notify the EPA as to the location and general description of its used oil management activities.

A Navy facility selling used automotive oil that is off-specification is not required to notify the EPA of its used oil management activities unless the used oil is sold directly to a person who burns it for energy recovery. If sold to such a person, the facility must notify the EPA of its used oil management activities, send the proper invoices with each shipment, and obtain the proper notices from the burner. The invoices and notices must be kept for a period of 3 yrs. If the facility sells used oil claiming to meet the specifications, it must obtain analysis to prove the used oil meets the specifications. These

records must be kept for 3 yrs. An operations log book must also be kept that details each shipment of used oil. These must also be kept for 3 yrs. The facility must notify the EPA or state, if authorized, of its used oil management activities. Notification is required because the facility will be the first to claim that the used oil meets the specifications.

These regulations became effective 9 December 1985. The only exception is the lead specification that became effective 29 May 1986. Besides the Federal regulations, many states and localities have regulations governing used oil burning. These regulations must also be met.

FUTURE REGULATIONS ON USED OIL BURNING

Future regulations call for stricter control over recycled used oil and also the listing of used oil as a hazardous waste. Phase I regulations on the blending and burning of used oil and hazardous waste are the regulations discussed previously. Phase II regulations are due to be proposed sometime in 1986. They may contain emission standards for burners of used oil. The lead specification for off-specification used oil fuel will be reviewed and may be lowered.

The proposed Recycled Used Oil Standards will regulate recycled oil.³ These standards will apply to generators and transporters of recycled oil along with the owners and operators of used oil recycling facilities. Used oil that is either burned for energy recovery or used to produce a fuel is considered a recycled oil. A fuel produced by blending used automotive oil and virgin fuel oil is subject to these regulations unless it can meet certain specifications that are identical to those in the current regulations. Other proposed regulations call for the listing of used oil as a hazardous waste. This regulation will list used oil as a hazardous waste but will leave the management of used oil recycling to the above regulations.

IMPACT OF REGULATIONS ON COFIRING

Used automotive oil is a waste generated by many Navy facilities. In the past, several facilities have cofired this waste.⁴ To determine the current level of used oil cofiring, NAVFAC Engineering Field Divisions and several Navy facilities were contacted regarding this practice. A summary of these results is presented in Appendix A. No facilities were found to be cofiring used automotive oil. Thus, the regulations will have no immediate effect on current cofiring practices.

The impact of the regulations on the disposal of used automotive oil through contractors will depend on how the regulations affect the contractor. Some contractors may no longer be able to accept the used oil and the facility will be forced to find another contractor or an alternate disposal method. The Navy facility selling the used oil is subject to certain requirements under the regulations as previously described.

The impact of the regulations on future plans to cofire used automotive oil can be minimized by meeting the used oil fuel specifications. This will limit the regulations that need to be complied with to cofire the used oil. As the lead content of used automotive oil drops, it will be come easier to meet the current lead specification and any lower specification that may be established. The impact of the yet-to-be-proposed Phase II regulations cannot be determined until they are established.

LEAD CONCENTRATION IN USED AUTOMOTIVE OIL

An accurate lead concentration in used automotive oil is difficult to obtain due to the phasedown of lead in gasoline. Lead in gasoline is the sole source of lead in automotive oil. In July 1985, the EPA lowered the maximum lead content in gasoline from 1.1 gr/gal to 0.5 gr/gal. In January 1986, it was lowered to 0.1 gr/gal. The EPA may even consider a total ban on lead in gasoline. Subsequently, the lead content in used automotive oil is dropping. It is unsure if the lead content will drop below 100 ppm. If it does and the used oil meets all other specifications, it will no longer be an off-specification used oil fuel. Table 2 shows the lead concentration of various groups of samples collected between 1981 and 1983.⁵ The current lead concentration will be lower than these figures.

TABLE 2. LEAD CONCENTRATIONS IN SAMPLES

Type of Oil	Number of Samples	Number/Percent Containing Lead	Concentration Units (ppm)				
			Mean	Median	Number in Percentile Category		Range
					75	90	
Used Automotive	96	94/97	1603	900	1600	2300	1 - 21,700
Direct From Generator*	40	39/97	2574	1470	2210	3300	5 - 21,900
From Waste Oil Collectors or Processors**	56	55/98	915	730	1110	1417	1 - 11,000
From Diesel Engines	5	4/80	29	13	----	----	<5 - 78
From Gasoline Engines***	87	87/100	2232	390	----	----	9 - 21,676

*Known to be only used automotive oil

**Collector/processor claimed the oil was only used automotive oil; however, the exact nature of the oil is unknown

***No distinctions between oil samples from leaded or unleaded gasoline; from the general population of motor vehicles, not Navy vehicles

LEAD CONCENTRATION IN FUEL OIL RECLAIMED (FOR)

FOR is a product of Navy reclamation operations. It is reclaimed from large volumes of waste oil and used as a boiler fuel. Included in the waste oil is used lubricating oil. This creates some concern about the lead concentration in FOR, which was found to be less than 60 ppm.⁶ The FOR specification, MIL-F-24951, does not include a lead concentration as a requirement.

AIR DISPERSION MODELING

A dispersion model is a mathematical representation of the meteorological transport and turbulent diffusion processes that occur in the atmosphere. It will predict the pollutant concentration due to emissions from various sources for a set of locations, called receptors, for various average time intervals. Facilities wishing to cofire used oil can estimate the effect it will have on ambient air quality through dispersion modeling. This may be required by local or state air permitting agencies to show compliance with their regulations. Air dispersion modeling for which the results are to be used for air permitting requirements should be done by experts in the field of dispersion modeling.

There are many off-the-shelf air dispersion models available. A set of air dispersion models developed by the EPA is available on the User's Network for Applied Modeling of Air Pollution (UNAMAP) system. Besides the UNAMAP system, there are other air dispersion models available for use. An air dispersion model will give valid results only when applied to the specific conditions for which it was developed. Some models can be applied to emissions from sources located in urban areas, while others work best for rural areas. Some other factors to be considered in choosing a model are number and type of emission sources, receptor distances from source, and terrain conditions.

For valid results, it is important that the data inputted to the model be as accurate as possible. The data required for most models include source data, receptor data and meteorological data. Source data required may be stack height and diameter, stack gas exit velocity and temperature, and pollutant emission rate. Receptor data required involve location of the receptors with respect to the emission source and, on some models, terrain elevation is needed. The meteorological data required by dispersion models usually involve some combination of upper air and surface observations, which are available from the National Climatic Center. The Naval Oceanography Command Detachment (NOCD) is the point of contact for obtaining weather information. It is important that the data be representative of the area to be modeled. NOCD can aid in determining from which upper air and surface observation stations the data should be obtained.

MODELING OF BOILER AT A TYPICAL NAVY FACILITY

The EPA's Single Source (CRSTER) model was used to determine the lead concentration in the ambient air as a result of cofiring used automotive oil in a boiler

located at a typical Navy facility. CRSTER is a point-source model that calculates hourly concentrations and averages these to determine concentration estimates for 3-hr, 8-hr, 24-hr, and annual time increments. It will calculate the concentration at 180 receptors located on a radial grid. The receptors were located every 10 deg on concentric circles at distances of 1, 2, 3, 4, and 5 km from the boiler. This particular version of CRSTER was adapted to be run on a microprocessor.

Boiler information required for the CRSTER model is given in Table 3. The boiler was assumed to be burning a blend of used automotive oil and virgin fuel oil with lead concentrations of 100, 75, and 50 ppm. The fuel blends were burned for 24 hr/day for an entire year.

TABLE 3. BOILER DATA

Boiler Size	165 M-BTU/hr
Fuel Rate	1000 gal/hr
Stack Height	44.3 m
Stack Diameter	2.1 m
Stack Gas Exit Temperature	470 °K
Stack Gas Volumetric Flow Rate	66,704 SCFM
Stack Gas Exit Velocity	8.8 m/s

An important consideration in the modeling of lead is the percentage of lead in the fuel that ultimately reaches the atmosphere. Some of the lead will remain in the boiler as ash. The percentage of lead leaving the boiler is reported to vary from 3 to 64 percent.^{7,8} Emission control devices will also remove a percentage of the lead from the exhaust gases. Although the boiler used in this study did have emission control devices, many Navy boilers are not equipped with such devices. To model a worst-case scenario, a zero-percent efficiency for the emission control devices was assumed. It was also assumed that 100 percent of the lead in the fuel exited the boiler.

The 10 highest annual mean concentrations were all less than one percent of the National Ambient Air Quality Standard (NAAQS). However, the 10 highest 24-hr concentrations were significantly higher than the 10 highest annual mean concentrations. Table 4 shows a comparison of annual and 24-hr concentrations for fuel lead concentrations of 50 and 100 ppm. Currently, the NAAQS is a 3-mo average of $1.5 \mu\text{g}/\text{m}^3$. The particular CRSTER version used was unable to generate a 3-mo average; therefore, a comparison of these two averages with the NAAQS must be made. The 24-hr concentrations are short-term averages and are not as significant when being compared with a 3-mo average. The annual concentrations agree with the results obtained by others doing similar air dispersion modeling.⁸

TABLE 4. COMPARISON OF AMBIENT AIR CONCENTRATIONS

100 ppm				50 ppm			
Annual		24-Hr		Annual		24-Hr	
Concen- tration	% NAAQS	Concen- tration	% NAAQS	Concen- tration	% NAAQS	Concen- tration	% NAAQS
0.00783	0.52	0.0899	6.0	0.00395	0.26	0.0454	3.0
0.00710	0.47	0.0782	5.2	0.00358	0.24	0.0395	2.6
0.00699	0.47	0.0758	5.1	0.00353	0.24	0.0383	2.6
0.00675	0.45	0.0749	5.0	0.00341	0.23	0.0378	2.5
0.00664	0.44	0.0670	4.5	0.00335	0.22	0.0338	2.3
0.00651	0.43	0.0660	4.4	0.00329	0.22	0.0333	2.2
0.00566	0.38	0.0651	4.3	0.00286	0.19	0.0329	2.2
0.00564	0.38	0.0634	4.2	0.00285	0.19	0.0326	2.1
0.00536	0.36	0.0633	4.2	0.00270	0.18	0.0317	2.1
0.00528	0.35	0.0605	4.0	0.00267	0.18	0.0305	2.0

The 10 highest 24-, 8-, and 1-hr concentrations were determined. These are significantly higher than the annual concentrations and are maximum short-term concentrations. They are usually of short duration and are not as significant as a long-term average. Appendix B contains complete modelling results.

The volume of used automotive oil disposed of in the modeled boiler is based on the lead concentration of the used oil and fuel oil. A 9-ppm concentration will be assumed for the fuel oil⁹ and a 3300-ppm concentration will be assumed for the used oil. This value was chosen because it represents a value that the lead concentration of 90 percent of the samples of known used automotive oil were below. Based on these figures and a continuous yearly operation of the boiler, 240,000 gal/yr of used automotive oil can be disposed of through boiler cofiring. This is an extremely large volume for one facility to generate and, while there are no figures available, it is likely that most Navy facilities generate a significantly lesser volume. Therefore, depending on boiler size, many facilities will be able to cofire a blended fuel with a lead concentration below 100 ppm.

The use of computer air dispersion modeling can be a useful tool in determining what effect used automotive oil cofiring will have on the ambient air quality. Which Navy agency will handle any dispersion modeling is not determined at this time.

AVAILABLE GUIDANCE FOR THE BURNING OF USED OIL

There are several reports available to Navy facilities to provide guidance on the burning of used oil. The *Used Oil and Solvent Recycling Data* issued by the Naval Energy and Environmental Support Activity (NEESA) and the *Use of Waste Oil*

as a *Supplemental Boiler Fuel* issued by the Naval Civil Engineering Laboratory (NCEL) are two such reports. Guidance is provided in the areas of segregation, storage, treatment, fuel analysis, blending, burner modifications, maintenance, and record-keeping. Several Technical Notes also issued by NCEL discuss the results of waste oil burning in Navy boilers.^{10,11} These works provide much of the guidance needed to burn used oil in Navy boilers; however, revisions will be needed to account for the new used oil regulations.

RECOMMENDATIONS

A study to be prepared for the Defense Environmental Leadership Project Office will evaluate the economic impact of various disposal options for used automotive oil; cofiring is one of these options. In conjunction with economic guidance, there will be a need for technical guidance. Reports exist that provide technical guidance for the use of used oil as a supplemental fuel in Navy boilers; however, there will be a need for this information to be updated with respect to the newest used oil regulations. It is recommended that a technical guidance manual be developed for the use of waste oil as a supplemental boiler fuel. Topics discussed should include storage and transportation, sampling, analysis, pretreatment, blending, emission control, permitting, record-keeping, and boiler modification and maintenance. The development of this manual should be delayed until the used oil regulations are finalized.

The 100-ppm lead specification required for used oil fuel to be cofired in Navy boilers is sufficient to meet the NAAQS for lead. The Navy should not consider adopting a lower lead specification than required in the current regulations. However, depending on the quantity of used automotive oil generated and boiler fuel usage rate, many facilities will be able to cofire a fuel blend with a lower lead concentration. This is highly recommended, since it will result in less impact on air quality and will allow easier compliance with any new lead specifications in future regulations.

Since used automotive oil may be a constituent of FOR, it is recommended that lead be included as a test parameter in the specifications for FOR. The concentration level can be that of the lead concentration in the used oil specification.

REFERENCES

1. D. R. Knudsen, D. R. Telesca, and J. L. Gallagher, *Initiation Decision Report on Thermal Destruction of Hazardous Wastes in Navy Boilers and Incinerators*, NSWC TR 85-115 (Draft), June 1985.
2. "Hazardous Waste Management System; Burning of Waste Fuel and Used Oil Fuel in Boilers and Industrial Furnaces," *Federal Register*, Vol. 50, No. 230, p. 49164, 29 November 1985.
3. "Hazardous Waste Management System; Recycled Used Oil Standards," *Federal Register*, Vol. 50, No. 230, p. 49212, 29 November 1985.
4. D. R. Telesca and M. A. Peterson, *Background Study for Thermal Destruction of Hazardous Wastes in Navy Boilers and Incinerators*, NSWC TR 84-267, October 1984.
5. Franklin Associates Ltd., *Composition and Management of Used Oils Generated in the United States*, PB 85-180297, November 1985.
6. Dr. Dennis W. Brinkman and Marvin L. Whisman, *Recovery of Navy Distillate Fuel from Reclaimed Product*, Vol. 1, Report No. B06508-3, June 1984.
7. Steven Chansky, et al, *Waste Automotive Lubricating Oil Reuse as a Fuel*, EPA 600-5-74-032, September 1974.
8. PEDCo-Environmental, Inc., *Risk Assessment of Waste Oil Burning in Boilers and Space Heaters* PB 85-103034, August 1984.
9. "Hazardous Waste Management System; Standards for the Management of Specific Wastes and Specific Types of Facilities," *Federal Register*, Vol. 50, No. 8, 11 January 1985.
10. T. T. Fu and R. S. Chapler, *Waste-Oil Boiler Firing Demonstration at NAS Miramar, San Diego, Calif.*, TN No: N-1618, January 1982.
11. T. T. Fu and R. S. Chapler, *Utilization of Navy Generated Waste Oils as Boiler Fuel--Economic Analysis and Laboratory Tests*, TN No: N-1570, February 1980.

APPENDIX A
RESULTS OF USED AUTOMOTIVE OIL BURNING SURVEY

Recently-proposed federal regulations (40 CFR, Part 266, Subparts D and E) regulate the burning of hazardous wastes and used oils. These regulations will affect the cofiring of used automotive oil in Navy boilers. For this reason, it is necessary to determine the current level of used automotive oil cofiring being practiced at Navy facilities. Environmental personnel at NAVFAC Engineering Field Divisions were contacted regarding this practice in their respective divisions. A summary of the results is presented below:

Engineering Field Division	Point of Contact	Comment
Northern	George Wiese AV 443-6280 (215) 897-6280	No facilities currently cofire used automotive oil; suggested contacting Naval Avionics Center in Indianapolis, Indiana
Southern	Craig Campbell AV 794-5510 (803) 743-5510	No facilities currently cofire used automotive oil; suggested contacting Naval Shipyard in Charleston, South Carolina
Western	John Gordon AV 439-8666 (206) 476-8666	No facilities currently cofire used automotive oil; it is sent to an oil reclamation facility where it is mixed with other oils and sold
Western (San Diego Area)	D.C. Fischer AV 958-5461 (619) 696-5461	One facility may be burning used oil--Miramar Naval Air Station
Atlantic	Paul Parker AV 564-9559 (804) 444-9559	A solid refuse boiler at Public Works Center in Norfolk, Virginia burns used oil; used automotive oil goes into Fuel Oil Reclaimed (FOR)
Chesapeake	Steve Buckley AV 288-3760 (202) 433-3760	No facilities currently cofire used automotive oil; it is disposed of through contractors

Several waste oil reports prepared for the Navy have given examples of Navy facilities that cofired waste automotive oil either directly or blended with other waste oils. These facilities, plus the several mentioned by NAVFAC personnel, were contacted to determine their current used automotive oil disposal practices. Both the past and current practice of each facility is described below in as much detail as was available:

NAVAL AIR STATION, FALLON, NEVADA
Ronald Nygren (702) 423-5161

Past Practice

Approximately 200 gal of waste oil were generated and burned each month. It was collected in drums at motor pool service areas and transported to the boiler plant and strained through a fine wire screen prior to introduction into primary fuel storage. The waste oil consisted primarily of used lube oil with some hydraulic oil and, rarely, small amounts of grease. A 200-hp boiler was operated for only 7 to 8 mo out of the year at 40 to 55 gal of fuel/hr. The fuel oil normally used was No. 6 fuel oil; No. 2 fuel oil was used as a backup fuel. The normal fuel was stored in a 12,000-gal tank and pumped through a filter into three burners. No special modifications to boiler equipment or operational changes were required to burn this waste oil and no adverse effects from its use were noted.

Current Practice

Waste oil is no longer burned in the boiler. The boiler was converted to natural gas as its main fuel. Possible contamination of the waste oil led local environmental agencies to begin questioning stack emissions and requesting daily reports. Waste oil is currently being disposed of on a single-time contract basis.

NAVAL AIR STATION WHIDBEY, ISLAND, WASHINGTON
Ken Buehn AV 820-2811 or 3348

Past Practice

The station collected and burned approximately 60,000 gal of waste oil and contaminated fuel/yr from two different type areas on the base. The waste oil burned consisted of a wide range of solvents, phenols, JP fuel, hydraulic fluids, and used lube oils. Enlisted personnel collected fuel, solvents, and used lube oil from the flight line in mobile bowzers (700- to 1000-gal capacity) and transported it to the boiler plant, where it was stored in a 25,000-gal underground tank. There was no treatment of this oil. Secondly, Public Works collected used lube oil from garages, service areas, and other locations throughout the base. This oil was placed in a 5000-gal tank to settle. The oil that rose was skimmed off the top and placed in a second tank (3000-gal capacity) to settle, and water was drained off the bottom periodically. After settling, this oil was transported to the underground tank at the boiler plant. The waste oil was burned in one of three 44M-BTU/hr boilers that used natural gas as the primary fuel and No. 2 as the backup fuel. One of the three burners was set aside to burn the waste oil. No modifications to the burner itself were required. The waste oil was pumped from the underground holding tank through a fine strainer and into the burner. While the waste oil was being burned, adjustments to the natural gas burners were made to compensate for fluctuations of the waste oil burner. Increased boiler cleaning activities were observed. The boiler utilizing waste oil experiencing increased ash accumulation and required cleaning twice a year. Boilers burning regular oil had to be cleaned only once every year or two.

Current Practice

Waste oil is no longer being burned. With JP fuel now being recycled, it is no longer available for fuel. Waste oil is now being disposed of through the Defense Property Disposal Office (DPDO).

PUBLIC WORKS CENTER, NORFOLK, VIRGINIA
Bill Thornton (804) 444-4853

Past Practice

FOR has been burned in boilers at this facility since 1979. It is obtained from Craney Island and was the primary supplemental fuel to the normal No. 6 fuel oil used. A secondary source of fuel was used lube oil and hydraulic fluid, which never amounted to more than 10,000 gal/yr. The waste oil was collected from the motor pool and service areas and was transported to the boiler plant. Here it was directly blended into existing No. 6 fuel oil tankage and was burned along with the regular fuel.

Current Practice

All waste oil is sent to Craney Island and then sold back to the facility as FOR; this includes waste automotive oil. FOR is still being burned in the boilers.

NAVAL AIR STATION, MIRAMAR, CALIFORNIA
Ms. Severance 959-3321

Current Practice

At one time, used oil was burned; however, FOR is currently being burned. Burning of waste oil was stopped due to the operational problems it presented. Problems with the state of California over whether it was a hazardous waste also led to its discontinuance. Used automotive oil is currently being sold.

NAVAL WEAPONS SUPPORT CENTER, CRANE, INDIANA
Dave Fry AV 482-1521

Current Practice

Waste automotive oil was burned in several boilers at this facility. The boilers have since been converted to natural gas and do not cofire the waste oil. The oil is collected and then sampled by the Environmental Protection group before it is disposed of.

NAVAL AVIONICS CENTER, INDIANAPOLIS, INDIANA
Dick Schatz (317) 353-3525

Past Practice

This facility burned approximately 5000 gal of waste oil/yr in one of three 17,000-lb/hr boilers used for steam production. The major source of the waste oil was machine shop cutting oil. Metal filings present in the oil were the major problem and were centrifuged prior to storing and burning. Used lube oil was the secondary source of waste oil and was collected from 60 vehicles in the transportation department and from a collection center provided for the individual to recycle waste oil. The boilers were designed to burn natural gas as primary fuel and have the capability of using No. 5 fuel oil as a backup. Storage of No. 5 fuel oil was maintained in six 1500-gal tanks, one of which was set aside to receive waste oil. Clean No. 5 fuel oil and waste oil were mixed at about a 50-50 ratio in this tank prior to burning.

Current Practice

The waste oil is no longer cofired in the boilers, since problems in proper operation of the boiler were encountered when burning this waste oil. Problems of increased smoke emissions and clogged filters due to dirt and sediment suspended in the waste oil were sometimes experienced. The waste oil is now disposed of through a contractor.

APPENDIX B

RESULTS OF COMPUTER MODELING AT A TYPICAL NAVY FACILITY

TABLE B-1. ANNUAL MEAN CONCENTRATION ($\mu\text{g}/\text{m}^3$) AT EACH RECEPTOR (Pb = 100 ppm)

Direction (deg)	Distance (km)				
	1.0	2.0	3.0	4.0	5.0
10	0.00469	0.00528	0.00472	0.00402	0.00345
20	0.00263	0.00326	0.00316	0.00282	0.00249
30	0.00190	0.00277	0.00273	0.00241	0.00210
40	0.00141	0.00189	0.00172	0.00147	0.00126
50	0.00108	0.00146	0.00137	0.00119	0.00104
60	0.00107	0.00140	0.00127	0.00108	0.000934
70	0.000694	0.000847	0.000745	0.000626	0.000537
80	0.000716	0.000917	0.000879	0.000772	0.000679
90	0.00115	0.00140	0.00128	0.00112	0.000949
100	0.00107	0.00133	0.00121	0.00106	0.000958
110	0.00124	0.00181	0.00183	0.00169	0.00157
120	0.00226	0.00415	0.00464	0.00448	0.00422
130	0.00277	0.00465	0.00507	0.00484	0.00449
140	0.00311	0.00483	0.00492	0.00448	0.00399
150	0.00326	0.00527	0.00523	0.00464	0.00405
160	0.00226	0.00369	0.00353	0.00304	0.00259
170	0.00177	0.00287	0.00268	0.00227	0.00191
180	0.00191	0.00300	0.00275	0.00231	0.00193
190	0.000978	0.00133	0.00199	0.000999	0.000841
200	0.00106	0.00149	0.00138	0.00117	0.000998
210	0.00153	0.00206	0.00184	0.00153	0.00128
220	0.00150	0.00163	0.00137	0.00113	0.000949
230	0.00176	0.00187	0.00156	0.00128	0.00107
240	0.00185	0.00194	0.00165	0.00136	0.00115
250	0.00147	0.00144	0.00117	0.000939	0.000770
260	0.00122	0.00115	0.000983	0.000827	0.000707
270	0.00118	0.00118	0.00108	0.000951	0.000837
280	0.000941	0.000877	0.000724	0.000589	0.000491
290	0.00101	0.00103	0.000870	0.000711	0.000589
300	0.00160	0.00177	0.00154	0.00128	0.00108
310	0.00219	0.00210	0.00168	0.00133	0.00108
320	0.00351	0.00302	0.00230	0.00177	0.00141
330	0.00536	0.00456	0.00351	0.00275	0.00222
340	0.00651	0.00566	0.00434	0.00337	0.00271
350	0.00699	0.00664	0.00518	0.00406	0.00329
360	0.00710	0.00783	0.00675	0.00564	0.00480

TABLE B-2. HIGHEST 24-HR CONCENTRATION ($\mu\text{g}/\text{m}^3$) AT EACH RECEPTOR (Pb = 100 ppm)

Direction (deg)	Distance (km)				
	1.0	2.0	3.0	4.0	5.0
10	0.0444 (221)	0.0493 (21)	0.0407 (99)	0.0366 (99)	0.0315 (99)
20	0.0460 (201)	0.0468 (166)	0.0456 (166)	0.0379 (166)	0.0309 (166)
30	0.0317 (139)	0.0322 (100)	0.0296 (100)	0.0249 (46)	0.0215 (46)
40	0.0372 (206)	0.0378 (45)	0.0291 (62)	0.0248 (62)	0.0213 (62)
50	0.0394 (176)	0.0366 (46)	0.0291 (46)	0.0228 (46)	0.0183 (46)
60	0.0307 (105)	0.0269 (70)	0.0246 (128)	0.0225 (128)	0.0196 (128)
70	0.0293 (105)	0.0228 (105)	0.0218 (274)	0.0199 (274)	0.0176 (274)
80	0.0273 (273)	0.0175 (273)	0.0171 (195)	0.0170 (195)	0.0148 (195)
90	0.0543 (140)	0.0298 (140)	0.0283 (28)	0.0255 (28)	0.0226 (28)
100	0.0287 (140)	0.0207 (55)	0.0192 (55)	0.0161 (55)	0.0134 (55)
110	0.0254 (240)	0.0226 (56)	0.0207 (56)	0.0194 (129)	0.0189 (129)
120	0.0411 (115)	0.0359 (115)	0.0357 (312)	0.0357 (312)	0.0337 (312)
130	0.0441 (213)	0.0394 (5)	0.0455 (340)	0.0505 (340)	0.0490 (340)
140	0.0550 (130)	0.0488 (57)	0.0425 (57)	0.0338 (57)	0.0283 (280)
150	0.0565 (123)	0.0457 (123)	0.0435 (279)	0.0398 (279)	0.0349 (279)
160	0.0349 (101)	0.0507 (109)	0.0432 (109)	0.0343 (109)	0.0296 (345)
170	0.0274 (145)	0.0531 (18)	0.0528 (18)	0.0449 (18)	0.0374 (18)
180	0.0356 (254)	0.0406 (244)	0.0362 (38)	0.0315 (150)	0.0275 (150)
190	0.0206 (259)	0.0261 (259)	0.0198 (259)	0.0150 (38)	0.0120 (38)
200	0.0242 (120)	0.0429 (344)	0.0467 (344)	0.0413 (344)	0.0353 (344)
210	0.0441 (255)	0.0386 (235)	0.0401 (235)	0.0355 (235)	0.0305 (235)
220	0.0382 (262)	0.0400 (235)	0.0398 (235)	0.0343 (223)	0.0290 (235)
230	0.0670 (262)	0.0417 (262)	0.0299 (262)	0.0230 (262)	0.0223 (63)
240	0.0596 (148)	0.0288 (151)	0.0245 (151)	0.0210 (125)	0.0179 (143)
250	0.0401 (102)	0.0305 (102)	0.0198 (102)	0.0159 (342)	0.0133 (342)
260	0.0347 (98)	0.0243 (165)	0.0256 (165)	0.0222 (165)	0.0187 (165)
270	0.0292 (246)	0.0153 (127)	0.0172 (127)	0.0173 (71)	0.0166 (71)
280	0.0297 (110)	0.0204 (110)	0.0196 (169)	0.0171 (169)	0.0144 (169)
290	0.0175 (267)	0.0206 (287)	0.0133 (287)	0.0113 (236)	0.0097 (187)
300	0.0304 (230)	0.0397 (188)	0.0383 (188)	0.0322 (188)	0.0266 (188)
310	0.0314 (238)	0.0226 (156)	0.0190 (156)	0.0172 (187)	0.0156 (187)
320	0.0426 (275)	0.0323 (271)	0.0323 (271)	0.0274 (271)	0.0228 (271)
330	0.0783 (214)	0.0653 (214)	0.0447 (214)	0.0318 (214)	0.0238 (214)
340	0.0758 (160)	0.0444 (160)	0.0321 (251)	0.0259 (184)	0.0213 (183)
350	0.0561 (160)	0.0429 (78)	0.0298 (78)	0.0231 (26)	0.0196 (26)
360	0.0900 (221)	0.0618 (221)	0.0400 (221)	0.0352 (67)	0.0322 (315)

NOTE: Number in parenthesis is day of the year in which concentration occurred.

TABLE B-3. HIGHEST 8-HR CONCENTRATIONS ($\mu\text{g}/\text{m}^3$) AT EACH RECEPTOR (Pb = 100 ppm)

Direction (deg)	Distance (km)				
	1.0	2.0	3.0	4.0	5.0
10	0.112 (91,2)	0.0689 (99,3)	0.0763 (99,3)	0.0684 (99,3)	0.0589 (99,3)
20	0.138 (201,2)	0.0762 (166,3)	0.0714 (166,3)	0.0583 (166,3)	0.0468 (166,3)
30	0.0886 (45,2)	0.0704 (205,3)	0.0713 (59,1)	0.0614 (59,1)	0.0558 (252,1)
40	0.108 (45,2)	0.109 (45,2)	0.0736 (45,2)	0.0513 (45,2)	0.0403 (62,1)
50	0.0857 (176,2)	0.0776 (46,2)	0.0598 (46,2)	0.0468 (46,2)	0.0379 (46,2)
60	0.0913 (105,2)	0.0725 (346,2)	0.0624 (346,2)	0.0558 (128,1)	0.0490 (128,1)
70	0.0870 (105,2)	0.0649 (105,2)	0.0654 (274,1)	0.0596 (274,1)	0.0527 (274,1)
80	0.0820 (273,2)	0.0510 (273,2)	0.0435 (195,3)	0.0424 (195,3)	0.0358 (195,3)
90	0.163 (140,2)	0.0893 (140,2)	0.0478 (140,2)	0.0430 (28,1)	0.0411 (28,1)
100	0.0860 (140,2)	0.0484 (140,2)	0.0346 (55,2)	0.0275 (173,3)	0.0244 (173,3)
110	0.0760 (240,2)	0.0669 (350,2)	0.0479 (350,2)	0.0401 (256,1)	0.0413 (256,1)
120	0.0981 (115,2)	0.0776 (226,1)	0.0841 (226,1)	0.0776 (226,1)	0.0696 (226,1)
130	0.116 (213,2)	0.0942 (5,2)	0.133 (340,2)	0.143 (340,2)	0.134 (340,2)
140	0.159 (130,2)	0.104 (130,2)	0.0840 (319,3)	0.0732 (319,3)	0.0619 (319,3)
150	0.152 (123,2)	0.0912 (123,2)	0.0742 (102,1)	0.0675 (102,1)	0.0585 (102,1)
160	0.789 (101,2)	0.0966 (114,3)	0.0838 (114,3)	0.0760 (345,1)	0.0676 (345,1)
170	0.0743 (145,2)	0.0875 (18,1)	0.0905 (18,1)	0.0778 (18,1)	0.0658 (98,1)
180	0.107 (258,2)	0.0896 (258,2)	0.0975 (150,1)	0.0913 (150,1)	0.0805 (150,1)
190	0.0608 (132,2)	0.0642 (132,2)	0.0465 (132,2)	0.0369 (38,1)	0.0299 (217,3)
200	0.0725 (120,2)	0.0589 (143,1)	0.0597 (344,3)	0.0521 (344,3)	0.0439 (344,3)
210	0.132 (255,2)	0.0868 (260,1)	0.0792 (260,1)	0.0644 (260,1)	0.0522 (260,1)
220	0.114 (262,2)	0.0881 (236,1)	0.0861 (235,3)	0.0751 (235,3)	0.0644 (235,3)
230	0.201 (262,2)	0.107 (262,2)	0.580 (144,2)	0.0505 (297,2)	0.0456 (63,2)
240	0.168 (148,2)	0.0862 (151,2)	0.0735 (151,2)	0.0598 (151,2)	0.0482 (151,2)
250	0.0980 (102,2)	0.0688 (102,2)	0.0567 (342,2)	0.0476 (342,2)	0.0399 (342,2)
260	0.103 (98,2)	0.0693 (165,1)	0.0711 (165,1)	0.0609 (165,1)	0.0509 (165,1)
270	0.0875 (246,2)	0.0458 (127,1)	0.0517 (127,1)	0.0466 (127,1)	0.0408 (127,1)
280	0.0892 (110,2)	0.0611 (110,2)	0.0545 (169,2)	0.0475 (169,2)	0.0399 (169,2)
290	0.0535 (287,2)	0.0619 (287,2)	0.0399 (287,2)	0.0269 (200,3)	0.0244 (200,3)
300	0.0899 (230,2)	0.0883 (188,3)	0.0893 (188,3)	0.0760 (188,3)	0.0633 (188,3)
310	0.0942 (238,2)	0.0644 (333,2)	0.0553 (333,2)	0.0422 (333,2)	0.0335 (156,3)
320	0.128 (275,2)	0.0742 (271,1)	0.0739 (271,1)	0.0627 (271,1)	0.0522 (271,1)
330	0.190 (161,2)	0.107 (214,2)	0.0729 (214,3)	0.0567 (214,3)	0.0448 (214,3)
340	0.220 (167,2)	0.105 (26,2)	0.0765 (26,2)	0.0585 (26,2)	0.0488 (270,3)
350	0.140 (172,2)	0.0985 (26,2)	0.0743 (26,2)	0.0589 (188,1)	0.0482 (188,1)
360	0.213 (221,2)	0.153 (25,2)	0.105 (25,2)	0.0814 (341,2)	0.0729 (341,2)

NOTE: (A,B) A is the day of the year in which the 8-hr concentration occurred.
 B is the 8-hr interval in which the 8-hr concentration occurred.
 1 = 0000 to 0800
 2 = 0800 to 1600
 3 = 1600 to 2400

TABLE B-4. ANNUAL MEAN CONCENTRATION ($\mu\text{g}/\text{m}^3$) AT EACH RECEPTOR ($\text{Pb} = 75 \text{ ppm}$)

Direction (deg)	Distance (km)				
	1.0	2.0	3.0	4.0	5.0
10	0.00353	0.00397	0.00355	0.00302	0.00260
20	0.00198	0.00245	0.00238	0.00212	0.00187
30	0.00143	0.00209	0.00205	0.00181	0.00158
40	0.00106	0.00142	0.00130	0.00111	0.000945
50	0.000810	0.00110	0.00103	0.000899	0.000784
60	0.000803	0.00106	0.000956	0.000815	0.000703
70	0.000522	0.000637	0.000560	0.000471	0.000404
80	0.000539	0.000690	0.000661	0.000581	0.000511
90	0.000865	0.00105	0.000961	0.000841	0.000748
100	0.000798	0.00100	0.000911	0.000800	0.000721
110	0.000936	0.00136	0.00138	0.00128	0.00118
120	0.00170	0.00313	0.00349	0.00337	0.00317
130	0.00208	0.00350	0.00382	0.00364	0.00338
140	0.00234	0.00364	0.00370	0.00337	0.00301
150	0.00245	0.00396	0.00393	0.00349	0.00305
160	0.00170	0.00278	0.00265	0.00228	0.00195
170	0.00133	0.00216	0.00202	0.00171	0.00143
180	0.00144	0.00225	0.00207	0.00174	0.00145
190	0.000736	0.000997	0.000896	0.000752	0.000633
200	0.000799	0.00112	0.00104	0.000883	0.000751
210	0.00151	0.00155	0.00139	0.00115	0.000962
220	0.00113	0.00122	0.00103	0.000848	0.000714
230	0.00132	0.00141	0.00118	0.000964	0.000808
240	0.00139	0.00146	0.00124	0.00102	0.000863
250	0.00111	0.00108	0.000881	0.000707	0.000579
260	0.000921	0.000865	0.000739	0.000622	0.000532
270	0.000890	0.000886	0.000813	0.000716	0.000629
280	0.000708	0.000660	0.000545	0.000443	0.000372
290	0.000759	0.000777	0.000655	0.000535	0.000443
300	0.00120	0.00133	0.00115	0.000961	0.000810
310	0.00165	0.00158	0.00126	0.000999	0.000816
320	0.00264	0.00228	0.00173	0.00133	0.00106
330	0.00403	0.00343	0.00264	0.00207	0.00167
340	0.00490	0.00426	0.00327	0.00254	0.00264
350	0.00526	0.00499	0.00390	0.00305	0.00248
360	0.00534	0.00589	0.00508	0.00425	0.00361

TABLE B-5. ANNUAL MEAN CONCENTRATION ($\mu\text{g}/\text{m}^3$) AT EACH RECEPTOR (Pb = 50 ppm)

Direction (deg)	Distance (km)				
	1.0	2.0	3.0	4.0	5.0
10	0.00237	0.00267	0.00238	0.00203	0.00174
20	0.00133	0.00165	0.00160	0.00142	0.00126
30	0.000961	0.00140	0.00138	0.00122	0.00106
40	0.000710	0.000954	0.000870	0.000742	0.000634
50	0.000544	0.000737	0.000690	0.000603	0.000526
60	0.000539	0.000709	0.000641	0.000547	0.000472
70	0.000350	0.000427	0.000376	0.000316	0.000271
80	0.000362	0.000463	0.000444	0.000390	0.000343
90	0.000591	0.000706	0.000644	0.000564	0.000502
100	0.000535	0.000671	0.000611	0.000537	0.000483
110	0.000628	0.000914	0.000924	0.000855	0.000790
120	0.00114	0.00210	0.00234	0.00226	0.00213
130	0.00140	0.00235	0.00256	0.00244	0.00227
140	0.00157	0.00244	0.00249	0.00226	0.00202
150	0.00164	0.00266	0.00264	0.00234	0.00205
160	0.00114	0.00186	0.00178	0.00153	0.00131
170	0.000892	0.00145	0.00135	0.00114	0.000962
180	0.000965	0.00151	0.00139	0.00116	0.000974
190	0.000494	0.000669	0.000601	0.000504	0.000424
200	0.000536	0.000754	0.000697	0.000593	0.000504
210	0.000772	0.00104	0.000929	0.000773	0.000645
220	0.000757	0.000820	0.000692	0.000569	0.000479
230	0.000888	0.000944	0.000780	0.000647	0.000542
240	0.000933	0.000980	0.000831	0.000686	0.000579
250	0.000742	0.000725	0.000591	0.000474	0.000389
260	0.000618	0.000580	0.000496	0.000417	0.000357
270	0.000597	0.000594	0.000545	0.000480	0.000422
280	0.000475	0.000443	0.000365	0.000297	0.000248
290	0.000510	0.000521	0.000439	0.000359	0.000297
300	0.000807	0.000894	0.000775	0.000645	0.000543
310	0.00111	0.00106	0.000846	0.000670	0.000547
320	0.00177	0.00153	0.00116	0.000892	0.000711
330	0.00270	0.00230	0.00177	0.00139	0.00112
340	0.00329	0.00286	0.00219	0.00170	0.00137
350	0.00353	0.00335	0.00261	0.00205	0.00166
360	0.00358	0.00395	0.00341	0.00285	0.00242

TABLE B-6. 10 HIGHEST 24-HR CONCENTRATIONS (Pb = 100 ppm)

Day	24-Hr Concentration ($\mu\text{g}/\text{m}^3$)	Direction (deg)	Distance (km)	% NAAQS ($1.5 \mu\text{g}/\text{m}^3$)
221	0.0899	0	2.0	6.0
214	0.0782	330	1.0	5.2
160	0.0758	340	1.0	5.1
167	0.0749	340	1.0	5.0
262	0.0670	230	1.0	4.5
158	0.0660	340	1.0	4.4
159	0.0651	340	1.0	4.3
161	0.0634	330	1.0	4.2
138	0.0633	340	1.0	4.2
163	0.0605	330	1.0	4.0

TABLE B-7. 10 HIGHEST 8-HR CONCENTRATIONS (Pb = 100 ppm)

Day	8-Hr Concentration ($\mu\text{g}/\text{m}^3$)	Direction (deg)	Distance (km)	% NAAQS ($1.5 \mu\text{g}/\text{m}^3$)
167	0.220	340	1.0	14.7
221	0.213	0	2.0	14.2
262	0.201	230	1.0	13.4
160	0.193	340	1.0	12.8
158	0.192	340	1.0	12.7
161	0.190	330	1.0	12.7
159	0.184	340	1.0	12.2
161	0.183	340	1.0	12.2
163	0.178	330	1.0	11.9
214	0.171	330	1.0	11.4

TABLE B-8. 10 HIGHEST 1-HR CONCENTRATIONS (Pb = 100 ppm)

Day	1-Hr Concentration ($\mu\text{g}/\text{m}^3$)	Direction (deg)	Distance (km)	% NAAQS ($1.5 \mu\text{g}/\text{m}^3$)
233	0.354	120	2.0	23.6
26	0.328	340	2.0	21.8
342	0.324	250	2.0	21.5
340	0.313	130	2.0	20.9
26	0.300	0	3.0	20.0
213	0.276	140	1.0	18.4
208	0.275	350	1.0	18.3
215	0.274	330	1.0	18.3
32	0.274	10	2.0	18.3
176	0.274	20	1.0	18.2

TABLE B-9. 10 HIGHEST 24-HR CONCENTRATIONS (Pb = 75 ppm)

<u>Day</u>	<u>24-Hr Concentration (ug/m³)</u>	<u>Direction (deg)</u>	<u>Distance (km)</u>	<u>% NAAQS (1.5 ug/m³)</u>
221	0.0677	0	2.0	4.5
214	0.0589	330	1.0	3.9
100	0.0570	340	1.0	3.8
167	0.0564	340	1.0	3.8
262	0.0504	230	1.0	3.4
158	0.0497	340	1.0	3.3
159	0.0490	340	1.0	3.3
161	0.0477	330	1.0	3.2
138	0.0476	340	1.0	3.2
163	0.0455	330	1.0	3.0

TABLE B-10. 10 HIGHEST 8-HR CONCENTRATIONS (Pb = 75 ppm)

<u>Day</u>	<u>8-Hr Concentration (ug/m³)</u>	<u>Direction (deg)</u>	<u>Distance (km)</u>	<u>% NAAQS (1.5 ug/m³)</u>
167	0.166	340	1.0	11.0
221	0.161	0	2.0	10.7
262	0.151	230	1.0	10.1
160	0.145	340	1.0	9.7
158	0.144	340	1.0	9.6
161	0.143	330	1.0	9.5
159	0.139	340	1.0	9.2
161	0.138	340	1.0	9.2
163	0.134	330	1.0	8.9
214	0.128	330	1.0	8.6

TABLE B-11. 10 HIGHEST 1-HR CONCENTRATIONS (Pb = 75 ppm)

<u>Day</u>	<u>1-Hr Concentration (ug/m³)</u>	<u>Direction (deg)</u>	<u>Distance (km)</u>	<u>% NAAQS (1.5 ug/m³)</u>
233	0.267	120	2.0	17.8
26	0.246	340	2.0	16.4
342	0.244	250	2.0	16.2
340	0.236	130	2.0	16.2
26	0.225	0	3.0	15.0
213	0.208	140	1.0	13.9
208	0.207	350	1.0	13.8
215	0.206	330	1.0	13.8
32	0.206	10	2.0	13.7
176	0.206	20	1.0	13.7

TABLE B-12. 10 HIGHEST 24-HR CONCENTRATIONS (Pb = 50 ppm)

<u>Day</u>	<u>24-Hr Concentration ($\mu\text{g}/\text{m}^3$)</u>	<u>Direction (deg)</u>	<u>Distance (km)</u>	<u>% NAAQS (1.5 $\mu\text{g}/\text{m}^3$)</u>
221	0.0454	0	2.0	3.0
214	0.0395	330	1.0	2.6
160	0.0383	340	1.0	2.6
167	0.0378	230	1.0	2.5
262	0.0338	340	1.0	2.3
158	0.0333	340	1.0	2.2
159	0.0329	340	1.0	2.2
161	0.0320	330	1.0	2.1
138	0.0319	340	1.0	2.1
163	0.0305	330	1.0	2.0

TABLE B-13. 10 HIGHEST 8-HR CONCENTRATIONS (Pb = 50 ppm)

<u>Day</u>	<u>8-Hr Concentration ($\mu\text{g}/\text{m}^3$)</u>	<u>Direction (deg)</u>	<u>Distance (km)</u>	<u>% NAAQS (1.5 $\mu\text{g}/\text{m}^3$)</u>
167	0.111	340	1.0	7.4
221	0.108	0	2.0	7.2
262	0.101	230	1.0	6.7
160	0.0972	340	1.0	6.5
158	0.0967	340	1.0	6.4
161	0.0958	330	1.0	6.4
159	0.0930	340	1.0	6.2
161	0.0925	340	1.0	6.2
163	0.0899	330	1.0	6.0
214	0.0899	330	1.0	5.7

TABLE B-14. 10 HIGHEST 1-HR CONCENTRATIONS (Pb = 50 ppm)

<u>Day</u>	<u>1-Hr Concentration ($\mu\text{g}/\text{m}^3$)</u>	<u>Direction (deg)</u>	<u>Distance (km)</u>	<u>% NAAQS (1.5 $\mu\text{g}/\text{m}^3$)</u>
233	0.179	120	2.0	11.9
26	0.165	340	2.0	11.0
342	0.163	250	2.0	10.9
340	0.158	130	2.0	10.5
26	0.151	0	3.0	10.1
213	0.139	140	1.0	9.3
208	0.139	350	1.0	9.3
215	0.139	330	1.0	9.3
32	0.138	10	2.0	9.2
176	0.138	20	1.0	9.2

DISTRIBUTION

	<u>Copies</u>		<u>Copies</u>
Commander		EPA Hazardous Waste Engineering	
Naval Facilities Engineering		Research Laboratory	
Command		Attn: Mr. E. Timothy Oppelt	1
Attn: Code 032P	3	Chief, Incineration Research Br.	
Code 111	1	26 West St. Clair	
Code 112	2	Cincinnati, OH 45268	
Code 04T1	1		
200 Stovall Street		Commanding Officer	
Alexandria, VA 22332		Northern Division	1
		Naval Facilities Engineering	
Commander		Command	
Naval Sea Systems Command		Attn: Code 114	
Attn: SEA-64	1	Philadelphia, PA 19112	
SEA-07	1		
SEA-56YP	1	Commanding Officer	
PMS402F12	1	Chesapeake Division	
Washington, DC 20362-5000		Naval Facilities Engineering	1
		Command	
Commander		Attn: Code 114	
Naval Air Systems Command		Bldg. 212 Washington Navy Yard	
Attn: AIR-4221B	1	Washington, DC 20374	
AIR-7123	1		
Washington, DC 20361		Commander	
		Atlantic Division	
Defense Environmental Leadership		Naval Facilities Engineering	1
Project Office		Command	
Attn: Mr. Joe Kaminsky	1	Attn: Code 114	
Room 202		Norfolk, VA 23511	
1717 H Street, NW			
Washington, DC 20006		Commanding Officer	
		Southern Division	
Commanding Officer		Naval Facilities Engineering	
Navy Petroleum Office		Command	
Attn: Code P40	1	Attn: Code 114	1
Mr. Norm Schmokel		P.O. Box 10068	
Cameron Station		Charleston, SC 29411	
Alexandria, VA 22304			
U.S. Army Environmental Hygiene			
Agency			
Attn: HSHB-ES-H	1		
Mr. Murray Brown			
Aberdeen Proving Ground, MD 21010			

DISTRIBUTION (Continued)

<u>Copies</u>	<u>Copies</u>
Commanding Officer Western Division Naval Facilities Engineering Command Attn: Code 113 P.O. Box 113 San Bruno, CA 94066 1	Director Defense Logistics Agency Attn: DLA-SCT Cameron Station Alexandria, VA 22314 1
Commanding Officer Western Division Northwest Environmental Section (Code 1143) Naval Facilities Engineering Command P.O. Box 2366 Silverdale, WA 98383 1	Director Office of Naval Acquisition Support Code 04H2 Washington, DC 20360-5100 1
Commanding Officer Western Division Code 1141 Naval Facilities Engineering Command 1220 Pacific Highway, Bldg. 131 San Diego, CA 92132 1	Commanding Officer Naval Amphibious Base, Little Creek Attn: Code N435 Norfolk, VA 23521 1
Commander Pacific Division Attn: Code 114 Naval Facilities Engineering Command Pearl Harbor, HI 96860 1	Commanding Officer Naval Weapons Support Center Attn: Code 092 Crane, IN 47522 1
Commanding Officer Naval Civil Engineering Laboratory Attn: Code L70 PM Code L71 Code L08A Tech. Library Port Hueneme, CA 93043 1 1 1	Commanding Officer Naval Undersea Warfare Engineering Station Attn: Code 07 Keyport, WA 98345 1
Office of the Chief of Naval Operations Attn: OP-451 Washington, DC 20350 1	Commanding Officer Naval Engineering and Environmental Support Activity Attn: Code 111C Code 112H Port Hueneme, CA 93043 1 1
	Officer in Charge Annapolis Laboratory David W. Taylor Naval Ship Research and Development Center, Center Detachment Attn: Code 2834 Annapolis, MD 21402 1

DISTRIBUTION (Continued)

	<u>Copies</u>		<u>Copies</u>
Commanding Officer Naval Air Propulsion Center Attn: Code PE31:AFK Trenton, NJ 08628	1	Oak Ridge National Laboratory Martin Marietta Env. Sys. Inc. Attn: Mr. Mack E. Lackey P.O. Box 4 Oak Ridge, TN 37831	1
Commanding Officer Naval Air Development Center Attn: Code 6061 Warminster, PA 18974	1	Hazardous Material Technical Center Attn: Mr. Torsten Rothman P.O. Box 816B Rockville, MD 20856-8168	1
Commanding Officer Naval Air Engineering Center Attn: Code 1823 Lakehurst, NJ 08733	1	Hazardous Waste Research Center College of Engineering Louisiana State University Baton Rouge, LA 70803	1
Commanding Officer Air Force Engineering Services Center Attn: RDVS (S. B. Joshi) Tyndall AFB, FL 32403-5000	1	The Chester Engineers, Inc. ASTM Subcommittee on Thermal Treatment of Hazardous Wastes Attn: Mr. Walter Zabban, Chairman P.O. Box 9356 Pittsburgh, PA 15225	3
Commanding Officer Naval Avionics Center Attn: Code 730 6201 East 21st St. Indianapolis, IN 46218	1	Commanding Officer Naval Submarine Base, New London Box 00 Groton, CT 06349-5000	1
Commander U.S. Army Toxic and Hazardous Materials Agency Attn: DRXTH-TE-A-D (Mr. R. Bertell) Aberdeen Proving Grounds, MD 21010	1	Commanding Officer Naval Submarine Base Pearl Harbor, HI 96860	1
Commander U.S. Army Construction Engineering Research Laboratory Attn: CERL-EN (Mr. W. Mikucki) P.O. Box 4005 Champaign, IL 61820	1	Commanding Officer Naval Submarine Base, Bangor Attn: Code N86 Bremerton, WA 98315-5000	1
National Bureau of Standards Attn: Dr. Walter Schaub B260 Polymers Bldg. 224 Washington, DC 20234	1	Commanding Officer Naval Submarine Base 140 Sylvester Road San Diego, CA 92106-3521	1
		Commanding Officer Naval Submarine Base Kings Bay, GA 31547	1

DISTRIBUTION (Continued)

	<u>Copies</u>		<u>Copies</u>
Commanding Officer Navy Public Works Center Bldg. 1A Great Lakes, IL 60088-5600	1	Commanding Officer Naval Air Station Dallas, TX 7511-9501	1
Commanding Officer U.S. Navy Public Works Center Guam, Mariana Islands FPO San Francisco, CA 96630-2937	1	Commanding Officer Naval Air Station Glenview, IL 60026-5000	1
Commanding Officer Navy Public Works Center Norfolk, VA 23511-6098	1	Commanding Officer Naval Air Station, Atlanta Marietta, GA 30060-5099	1
Commanding Officer Navy Public Works Center Pearl Harbor, HI 96860	1	Commanding Officer Naval Air Station New Orleans, LA 70143-4000	1
Commanding Officer Navy Public Works Center Naval Air Station Pensacola, FL 32508-6500	1	Commanding Officer Naval Air Station South Weymouth, MA 02190-5000	1
Commanding Officer Navy Public Works Center Naval Base San Diego, CA 92136-5113	1	Commanding Officer Naval Air Station Willow Grove, PA 19090-5010	1
Commanding Officer Navy Public Works Center San Francisco Bay P.O. Box 24003 Oakland, CA 94623	1	Commanding Officer U.S. Naval Air Station Bermuda FPO New York, NY 09560	1
Commanding Officer U.S. Navy Public Works Center U.S. Facility Subic Bay, Luzon, Republic of the Philippines FPO San Francisco, CA 96651-2900	1	Commanding Officer Naval Air Station Cecil Field, FL 32215-5000	1
Commanding Officer U.S. Navy Public Works Center Yokosuka, Japan FPO Seattle, WA 98762-3100	1	Commanding Officer U.S. Naval Air Station Guantanamo Bay, Cuba FPO New York, NY 09593	1
		Commanding Officer Naval Air Station Jacksonville, FL 32212-5000	1

DISTRIBUTION (Continued)

	<u>Copies</u>		<u>Copies</u>
Commanding Officer Naval Air Station Key West, FL 33040-5000	1	Commanding Officer Naval Air Station, Miramar San Diego, CA 92145-5000	1
Commanding Officer Naval Air Station Norfolk, VA 23511	1	Commanding Officer Naval Air Station, North Island San Diego, CA 92135	1
Commanding Officer Naval Air Station, Oceana Virginia Beach, VA 23460-5120	1	Commanding Officer U.S. Naval Air Station, Cubi Point Subic Bay, Luzon, Republic of the Philippines	1
Commanding Officer Naval Air Station Adak, AK FPO Seattle, WA 98791-1200	1	FPO San Francisco, CA 96654-1200	
Commanding Officer Naval Air Station Attn: Code UL-2 Alameda, CA 94501	1	Commanding Officer Naval Air Station, Chase Field Beeville, TX 78103-5000	1
Commanding Officer Naval Air Station Barbers Point, HI 96862	1	Commanding Officer Naval Air Station Corpus Christi, TX 78419-5000	1
Commanding Officer Naval Air Station Fallon, NV 89406	1	Commanding Officer Naval Air Station Kingsville, TX 78363	1
Commanding Officer U.S. Naval Air Station, Agana Guam, Mariana Islands FPO San Francisco, CA 96637-1200	1	Commanding Officer Naval Air Station, Memphis (84) Millington, TN 38054-5000	1
Commanding Officer Naval Air Station Lemoore, CA 93246-0001	1	Commanding Officer Naval Air Reserve Center, Columbus Bldg. 1001, Rickenbacker AFB Columbus, OH 43217	1
Commanding Officer Naval Air Station Moffett Field, CA 94035-5000	1	Commanding Officer Naval Air Reserve Center, Olathe 300 Navy Dr. Industrial Airport, KS 66031-0013	1
Commanding Officer Naval Air Station, Widbey Island Oak Harbor, WA 98278-5000	1	Commanding Officer Naval Air Reserve Center Hangar 4 Mod 5, Naval Air Station Lemoore, CA 93246-0018	1

DISTRIBUTION (Continued)

<u>Copies</u>	<u>Copies</u>
Commanding Officer Naval Air Reserve Center 6201 32nd Ave., South Minneapolis, MN 55450-2898 1	Commanding Officer Naval Air Rework Facility Naval Air Station, North Island San Diego, CA 92135 1
Commanding Officer Naval Air Reserve Center, Moffett Naval Air Station Moffett Field, CA 94035 1	Commanding Officer U.S. Naval Air Station Sigonella, Catania, Sicily FPO New York, NY 09523 1
Commanding Officer Naval Air Reserve Center, Patuxent River Naval Air Station Patuxent River, MD 20670 1	Commanding Officer Naval Ordnance Station Attn: OE Indian Head, MD 20640-5000 1
Commanding Officer Naval Air Reserve Center, Miramar Naval Air Station, Miramar Bldg. 630 San Diego, CA 92145 1	Commanding Officer Naval Ordnance Station Louisville, KY 40214 1
Commanding Officer Naval Air Rework Facility Naval Air Station Alameda, CA 94501 1	Commanding Officer Naval Weapons Station Charleston, SC 29408 1
Commanding Officer Naval Air Rework Facility Marine Corps Air Station Cherry Point, NC 28533 1	Commanding Officer Naval Weapons Station Concord, CA 94520-5000 1
Commanding Officer Naval Air Rework Facility Naval Air Station Jacksonville, FL 32212 1	Commanding Officer Naval Weapons Station, Earle Colts Neck, NJ 07722-5000 1
Commanding Officer Naval Air Rework Facility Naval Air Station Norfolk, VA 23511 1	Commanding Officer Naval Weapons Station Seal Beach, CA 90740-5000 1
Commanding Officer Naval Air Rework Facility Naval Air Station Pensacola, FL 32508 1	Commanding Officer Naval Weapons Station Attn: Code 04 Yorktown, VA 23691-5000 1
	Commander Puget Sound Naval Shipyard Bremerton, WA 98314-5000 1

DISTRIBUTION (Continued)

	<u>Copies</u>		<u>Copies</u>
Commander		Internal Distribution	
Charleston Naval Shipyard			
Attn: Code 400	1	E	1
Public Works Office		E31 (GIDEP)	1
Naval Base		E211 (Hall)	1
Charleston, SC 29408		E231	10
		G	1
Commander		H30	1
Long Beach Naval Shipyard	1	H31 (Knudsen)	1
Long Beach, CA 90822-5099		H31 (Skinner)	1
		H31 (R. Gibbs)	1
Commander		H31 (Robinson)	1
Pearl Harbor Naval Shipyard		R10G	1
Box 400	1		
Pearl Harbor, HI 96860			
Commander			
Philadelphia Naval Shipyard	1		
Philadelphia, PA 19112			
Commander			
Portsmouth Naval Shipyard	1		
Portsmouth, NH 03804-5000			
Commander			
Norfolk Naval Shipyard			
Attn: Code 441 (Bldg. 1500)	1		
Portsmouth, VA 23709-5000			
Commander			
Mare Island Naval Shipyard	1		
Vallejo, CA 94592			

END

5-87

DTIC